

RUNNING HEAD: The Effect of Extended Direction of Attention on Pressure Sensations

The Effect of Extended Direction of Attention on Subsequent Pressure Sensations

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Abstract

Previous literature has shown a style of perceptual amplification in patients suffering from chronic pain conditions, compared to healthy controls (Hollins et al. 2009; McDermid, Rollman, & McCain 1996). The underlying mechanism for this sensory amplification is disagreed upon by researchers within the domain. Some claim that negatively-valenced emotional response to unpleasant stimuli is the culprit (VanDamme 2017; McDermid, Rollman, & McCain 1996). Others believe the phenomenon occurs due to habitual direction of attention toward both unpleasant and neutral stimuli (Hollins et al. 2009). It is unclear whether this phenomenon occurs only in those with chronic pain conditions, or is generalizable to all people. The current study used a sample of healthy participants and neutral pressure stimuli to assess the role of attention in this phenomenon. Results show that direction of attention for an extended period of time caused perceptual amplification of highly similar sensations to those attended to. The sensations which were amplified were neutral in nature, indicating that attention is likely the underlying factor. Dissimilar sensations within the same sensory domain (touch) were not amplified. The results of this experiment provide an explanation for the development of generalized hypervigilance, and suggest that a better description for this phenomenon is *diversified* hypervigilance.

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Sensations

The primary aim of the present study is to clarify the mechanisms responsible for previously observed perceptual amplification of noxious sensations in patients with chronic pain conditions, such as fibromyalgia, temporomandibular disorders, and rheumatoid arthritis (Hollins et al. 2009; McDermid, Rollman, & McCain 1996). According to the Generalized Hypervigilance Hypothesis (GHH) of McDermid et al., this perceptual amplification is due to increased levels of body vigilance, often referred to as hypervigilance. Hypervigilance is thought of as a perceptual style involving habitual direction of attention toward bodily sensations, especially painful or unpleasant ones. Hollins and Walters (2016) attempted to induce a mild transient state of hypervigilance in healthy individuals, with limited success. The current study hopes to expand on Hollins and Walters (2016) by creating a more effective experimental manipulation, as well as measuring a wider domain of variables that will more effectively assess the validity of the GHH. Furthermore, the aim of the current study is to test the Attentional Gain Model of hypervigilance proposed by Hollins and colleagues (Hollins et al. 2009).

Chapman (1978) first observed a tendency for chronic pain patients to have increased vigilance to somatic distress signals. This concept of hypervigilance was expanded when McDermid, Rollman, and McCain (1996) compared pain tolerance and threshold of fibromyalgia (FM) patients, rheumatoid arthritis (RA) patients, and healthy controls. Tolerance and threshold were measured for pressure and noise stimuli. McDermid and colleagues found that both FM and RA patients had significantly lower pain threshold and tolerance for pressure sensations than healthy controls (HC). FM and RA patients also had significantly lower tolerance for noise

sensations than healthy controls. This provides support for claims that chronic pain conditions are associated with an increase in sensitivity to stimuli.

Based on these findings, McDermid, Rollman, and McCain (1996) proposed the Generalized Hypervigilance Hypothesis, which states that patients with some chronic pain conditions, such as FM and RA, have a cognitive style of increased attention to noxious sensations, combined with a preoccupation with pain. They suggested that this cognitive style results in lower thresholds and tolerances for noxious stimuli. Founders of this model define a sensation as noxious if it is perceived as painful, unpleasant, or aversive. However, Hollins et al. (2009) investigated what kind of stimuli were affected by this phenomenon and found that some neutral as well as noxious stimuli were experienced more intensely by chronic pain patients, compared to healthy controls.

Hollins et al. (2009) proposed that hypervigilance is associated with amplification of a range of stimuli, not just noxious stimuli. They recorded the subjective ratings of the intensity and unpleasantness of pressure and noise stimuli of FM patients, TMD patients, and healthy controls (HC). They used a task in which the end of a weighted rod was placed on to the forearm of participants, with a variety of weights. Participants were asked to rate the intensity and unpleasantness of these pressure sensations on a scale from 0-100, as well as to classify the sensations as “painful,” “unpleasant but not painful,” or “neutral.” Similarly, 24 sounds of randomly ordered intensity were presented to participants, and they were asked to rate the intensity and unpleasantness of these stimuli from 0-100. Furthermore, all participants completed the Pennebaker Inventory of Limbic Languidness (PILL), a measure of hypervigilance.

FM and TMD patients reported significantly higher intensity ratings for both pressure and noise stimuli, compared to healthy controls. Participants' ratings of unpleasantness showed a significant difference between FM patients and all other participants. TMD and HC participants showed no statistically significant differences in unpleasantness ratings (Hollins et al. 2009). Furthermore, FM and TMD patients had significantly higher PILL scores compared to the healthy controls, suggesting that their body vigilance is significantly higher than HCs.

Based on these findings, Hollins et al. (2009) proposed the Attentional Gain Model of hypervigilance (AGM). This model suggests that both noxious stimuli, and *potentially* noxious stimuli, get amplified due to habitual direction of attention toward these kinds of stimuli. Potentially noxious stimuli include stimuli that have become associated with a noxious event, or are within the same sensory domain. This feature differentiates the AGM from the GHH.

Some hypothesize that hypervigilance, and its resulting increase in sensitivity, occur only when a person's fear pathway is activated, or when a person desires to avoid pain (Van Damme 2016). The study on which this hypothesis is based used vibrating skin contactors to compare the perceptive threshold, and ability to distinguish differences between a series of vibrations. They compared groups of FM patients and HCs. Contactors were placed on eight body locations: both upper arms, both forearms, both legs just below the knee, and both legs just above the ankle. The intensity of contactor vibration was calibrated for each participant. The intensity of vibration was increased until participants were able to detect the vibration. Then, participants performed a task in which they judged whether two combinations of vibration stimuli differed from one another. The investigators of this study attempted to test the role of attention by using two experimental conditions, an unpredictable condition and a predictable condition. In the unpredictable

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condition, participants were told that the locations of contactor vibrations would be evenly distributed. In the predictable condition, participants were told that contactor vibrations would occur at one specific location. Then trials were administered in six blocks of 88 trials, with different combinations of valid/invalid, and same/different trials. The results of this study showed only a significant difference between groups of baseline contactor vibration intensity, where FM patients required a more intense vibration to reach threshold of perception than HCs. No difference in ability to detect stimulus differences was found between groups, or conditions. This contradicts previous findings that FM patients have increased sensitivity to tactile sensations.

Based on the lack of significant results in this 2016 study, Van Damme suggests that chronic pain patients must fear bodily threat in order to experience results of hypervigilance. However, this interpretation of results is not convincing, and only adds to the confusion surrounding the discussion of hypervigilance. Furthermore, the methods of the study showed no indication that the experienced frequency of vibration was regulated, and the fact that intensity of vibrations were tailored to each participant introduces inconsistencies. Lastly, the manner in which the authors attempted to manipulate attention, using unpredictable/predictable conditions, and invalid/valid and same/different trials, was apparently unsuccessful. In order to conclude that an emotional factor is responsible for the increase in perception, more investigation must be conducted. Similarly, the role of attention in this process cannot be discounted based on the findings of this study.

It is interesting to compare the bodily sensitivity of patients with FM and panic disorder. Patients diagnosed with panic disorder experience frequent panic attacks, which are highly

unpleasant and can even be painful. Panic attacks involve increased heart rate, chest pain, dizziness, lightheadedness, and other unpleasant symptoms. Previous studies provide evidence of an association between body vigilance and panic disorder symptoms (Telch et al. 1993; Schmidt, Lerew & Trakowski 1997). Patients in these studies were adept at detecting changes in bodily sensations, especially those that traditionally are indicative of a panic attack, such as increased heart rate and lightheadedness/dizziness. These studies also show that cognitive-behavioral therapy designed to decrease vigilance to bodily sensations such as increased heart rate and dizziness produces marked decreases in rates of panic attacks.

Cognitive-behavioral therapy (CBT) utilized by Telch (1993) and Schmidt (1997) focused on desensitizing patients to bodily sensations that traditionally signal the onset of a panic attack, foremost increases in heart rate, and dizziness or lightheadedness. Patients were given caffeine, a substance that naturally increases heart rate. Patients were then trained to recognize that an increase in heart rate does not always indicate the onset of a panic attack. By training these patients to regard formerly noxious stimuli as non-threatening, rates of panic disorder symptoms decreased significantly. These CBT techniques caused patients to direct less attention to these stimuli. It may be that these stimuli were less strongly perceived after CBT, although the study does not demonstrate this.

Rost, Van Ryckeghem, Schulz, Crombez, and Vogeles (2017) tested FM patients' ability to detect bodily sensations, specifically number of heartbeats. This study recorded participants' Heart Rate Variability (HRV), a physiological measure of body vigilance. Previous studies show there is an inverse relationship between HRV and body vigilance (Rost et al. 2017). This study utilized both FM patients and HCs. Experimenters recorded participants' heart rate variability,

and had participants attempt to count their heartbeats over a variety of time periods. They found that HRV was significantly lower for FM patients compared to healthy controls. However, they found no difference in the detectability of heartbeats between FM patients and HCs. Heartbeats are rarely noxious for FM patients, so these findings are consistent with the GHH, which predicts perceptual amplification only of noxious sensations. From the perspective of the AGM, the lack of significant differences in heartbeat detection can be attributed to the absence of a reason to direct attention toward heart sensations. Heart beats are not associated with the negative symptoms of FM, so FM patients have little reason to direct attention toward these sensations more frequently than do HC participants.

We hypothesize that habitual attention is the mechanism for the phenomenon of hypervigilance. Fear of noxious events, and the habitual experience of noxious events merely act to direct attention to bodily sensations. Some hypothesize that hypervigilance occurs when a certain fear pathway is activated, or when a person desires to avoid pain (Van Damme 2016). However, the design of the study making these claims is questionable. The aim of the current study is to sift through confusion produced by previous studies to make the origin of this phenomenon clear.

Purpose of the Present Study

The present study aims to uncover the mechanisms behind perceptual amplification of chronic pain conditions. We hypothesize that direction of attention is the reason for observed perceptual amplification. In order to investigate this, we plan to manipulate attention and hold all other variables constant. In order to achieve this two groups will be used, an experimental group and a control group. Both groups will receive identical touch stimuli. Members in the

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experimental group will direct attention toward these sensations, while members of the control group will perform a task that directs their attention away from these sensations. After this manipulation, all participants will complete an identical series of tasks and questionnaires. These tasks ask participants to rate sensation intensity of light touch sensations; and to rate intensity, unpleasantness, and classify stronger pressure sensations. Responses on these subsequent tasks and questionnaires will be compared between groups to evaluate the effect of attention on sensory experience. The present experiment utilizes participants free of chronic pain disorders, this allows the role of attention to be assessed cleanly. Furthermore, this experiment does not instill a sense of fear, and merely forces participants to direct their attention to the detection of light tactile stimuli. These two aspects of this experiment are what will distinguish any significant findings from those of prior research.

This experiment tests four hypotheses. 1.) Participants with higher body vigilance will have a significantly lower threshold of detection of light pressure. 2.) Participants who direct attention toward detection of light tactile stimuli will rate subsequent stimuli more intensely than a group who did not direct attention toward these stimuli. 3.) Participants in the detection condition will have significantly higher ratings on another pressure-perception task (the weighted rod task) than participants in the distraction condition. 4.) Participants who direct attention toward the detection of light touch sensations will experience more rapid increases in ratings of subsequent sensations than participants who did not direct attention.

Methods

Participants

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Participants in this study were drawn from a pool of undergraduate introductory psychology students at The University of North Carolina at Chapel Hill. There were 80 participants, 22 male and 58 female. Participants were granted research credit for their participation. Recruitment was done using the Psychology Department's online participant pool system. Participants were assigned to experimental conditions using alternating assignment, as part of a yoked-control design.

Materials

This study utilized a variety of questionnaires, a Von Frey Hair detection task, a distraction task, a line scaling exercise, a Von Frey Hair subjective scaling task, and a weighted rod task.

Questionnaires

In order to measure participants' hypervigilance, researchers used the Pennebaker Inventory of Limbic Languidness (PILL: Pennebaker, 1983), the Body Vigilance Scale (BVS: Schmidt et al. 1997), and the Pain and Vigilance Awareness Questionnaire (PVAQ: McCracken 1997). Three questionnaires for bodily vigilance were used. Each of these questionnaires measure different facets of vigilance, providing a well-rounded picture of participants' perceptive habits. The PILL is an implicit measure of vigilance that measures frequency of bodily symptoms. The BVS and PVAQ are both explicit measures of vigilance. The BVS measures vigilance to bodily sensations, and the PVAQ measures vigilance to pain.

The PILL asks participants to rate how frequently they experience 54 bodily symptoms. These bodily symptoms include items such as "Racing heart," "Eyes water," and "Hot flashes." . Participants rate the frequency of these events using a letter scale ranging from A to E: "A: Have

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never or almost never experienced the symptom;” “B: Less than 3 or 4 times per year;” “C: Every month or so;” “D: Every week or so;” “E: More than once every week.” The PILL is scored by counting every item that was given a response of C, D, or E, indicating high frequency. Higher scores on the PILL indicate higher vigilance (Pennebaker 1983).

The BVS asks participants to rate their sensitivity to internal bodily sensations, over the past week. The instructions include heart palpitations and dizziness as examples of bodily sensations. The first two items ask the participant to rate how apt two description are of himself/herself. These two descriptions are “I am the kind of person who pays close attention to internal bodily sensations.” and “I am very sensitive to changes in my internal bodily sensations.” Scales for these items range from 0 (Not at all like me) to 10 (Extremely like me). The third item asks them to report the average amount of time they spend daily “scanning” their body for sensations, such as sweating, heart palpitations, and dizziness. This item uses a scale from 0 (No time) to 100 (All of the time). In the final section, participants are asked to rate how much attention they pay to a list of 15 sensations, on a scale from 0 (None) to 10 (Extreme). These sensations include heart palpitations, chest pain/discomfort, numbness, shortness of breath/smothering, dizziness, hot flash, sweating/clammy hands, among others (Schmidt et al. 1997). The BVS is scored by summing the responses from the first two items, the third item divided by ten, and the average of all responses on the 15 items about specific sensations. High scores indicate high levels of body vigilance.

The PVAQ asks participants to consider their behavior over the past two weeks, and to indicate how frequently a list of 16 descriptions were true of them. Frequency is indicated on a scale from 0 (never) to 5 (always). These descriptions are focused on how sensitive and attentive

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a participant is to the presence, location, and intensity of pain (e.g. “I am very sensitive to pain.” “I know immediately when pain starts or increases.” “I keep track of my pain level.”). This questionnaire contains two reverse score items “I find it easy to ignore pain.” and “I do not dwell on pain.” The PVAQ is scored by taking the sum of all items, with reverse scores for the two items listed previously. High scores indicate high vigilance to pain.

Other questionnaires used include the State Trait Anxiety Inventory (STAI: Spielberger 1983), the Pain Catastrophizing Scale (PCS: Sullivan et al. 1995), and the Positive and Negative Affect Scale (PANAS: Watson, D., Clark, L. A., & Tellegan, A. 1988). These questionnaires were used to ensure that these factors were not affecting the results of the current experiment.

Previous studies show that perception can be altered when a person is in a state of high anxiety (Spielberger 1983). To measure anxiety, the current study utilized the State portion of the State Trait Anxiety Inventory. This questionnaire was used to ensure that our sample was not experiencing a significant amount of anxiety, and to ensure that our experimental manipulation did not cause any group to experience significantly different levels of anxiety. This questionnaire instructs participants to “indicate how you feel right now, that is, at this moment.” Participants respond to 20 statements about their current mood and level of arousal, using a visual scale with four answer choices ranging from “Not at all” to “Very much so.” Examples of statements include “I feel tense.” “I feel frightened.” “I am presently worrying over possible misfortunes.” and “I feel jittery.” Some of the reverse scored statements include “I feel calm.” “I feel secure” “I feel self-confident” “I feel pleasant.” A high score indicates high levels of anxiety at the time the questionnaire was administered.

The PCS is used to measure pain catastrophizing. Pain catastrophizing can affect perception, particularly perception of pain stimuli (Sullivan et al. 1995). The PCS reminds participants about how the experience of pain is universally experienced. The instructions then read that the current questionnaire is interested in thoughts and feelings people experience when they are in pain. Participants are asked to think back to memories of pain, and to rate the degree to which they have experienced the thoughts and feelings described by 13 items. These items include “I worry all the time about whether the pain will end.” “I feel I can’t stand it anymore.” “I can’t seem to keep it out of my mind.” Participants rate the degree to which they have these thoughts on a scale ranging from 0 (not at all) to 4 (all the time). Higher scores indicate higher levels of catastrophizing.

The PANAS is a scale designed to record feelings and emotions. The current study is utilizing it to ensure that the mood of experimental groups are not significantly different. Previous studies have shown that mood can affect perception. The PANAS contains 20 items, each of which is a single word denoting a mood or emotion. These include “Interested,” “Distressed,” “Strong,” “Irritable,” “Ashamed,” “Determined,” among others. Participants are asked to “Indicate to what extent you feel this way TODAY” for each item. Participants make their indications on a 5-point Likert scale ranging from “Very slightly or not at all” to “Extremely.” This questionnaire is scored by summing the responses to the Likert scale for all positive and negative moods/emotions, respectively. This produces two scores, one measuring positive affect, and one measuring negative affect. The higher one’s score, the more strongly one is experiencing that valence of emotion.

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Participants also completed a Demographic Information Form, and the Current Pain Questionnaire, two instruments developed in our lab. The Demographic Information Form asked participants to denote their age, gender, ethnic category, racial category, and handedness. The Current Pain Questionnaire requires participants to rate the average intensity, unpleasantness, and frequency of pain of the last two weeks. Next, participants are asked to rate the intensity and unpleasantness of any current pain. These first five items are rated on a scale from 0 to 100. The remaining three items ask about the location of any current pain, existence of chronic pain, and current use of pain medication.

Von Frey Filaments

Von Frey Filaments are nylon hairs often used to apply light touch stimuli to the skin of experimental participants. These filaments are constructed such that when applied to a surface, they will not exceed a certain threshold of downward force. Each filament in a set is constructed with a certain stiffness such that it buckles when this threshold is reached. This buckling ensures that once this threshold is reached, no additional force is exerted. Multiple tasks in this study require application of light touch sensations with exact and consistent force. To accomplish this, a set of von Frey filaments was used with strengths ranging from .008 g to 60g.

Fishy Game

The distraction condition plays an online video game called “Fishy!”. This game is a free to play online flash game, and can be found online at <http://fishy-flash-game.com/>. In this game, the player controls a small fish using the arrow keys. The objective of the game is to eat fish that are smaller than the user’s fish, and avoid being eaten by fish that are larger. As the user

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consumes fish, their score and the size of their fish increases. When a user's fish is eaten, the game ends and the user is assigned a final score. This game was utilized in the distraction task of this study. Each game session was considered a trial, and the measured variable was the user's final score at the end of each game session. These scores were recorded and summed for each member of the control group.

Procedure

First, participants gave written informed consent. Next, participants filled out the Demographic Information Form, and then the Current Pain Questionnaire.

Next, the participant completed the first task. Participants in the experimental condition performed a detection task, and participants in control condition completed a distraction task.

Detection Task

The experimental condition consisted of a detection task. Detection threshold for the nylon filaments was measured using two-interval forced-choice tracking.

First, the experimenter explained that he would be applying light touch sensations to the ventral side of the participant's forearm, using delicate nylon filaments called von Frey Hairs. The experimenter showed a filament to the participant, and explained what it was. Then the experimenter explained the detection task.

Participants placed their right arm, palm up, underneath a cloth barrier. The experimenter explained that the job of the participant was to detect when a stimulus was presented. On each trial, a stimulus was presented during one of two test intervals separated by two seconds. Each

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test interval lasted one second. Each stimulus was presented for half of a second at some point during the one-second test interval. Trials were cued using a PowerPoint presentation that shows a series of lightbulbs. A gray lightbulb signaled that no trial was currently occurring. The bulb turned yellow for two seconds, indicating that a trial was about to occur. The bulb then turned green for one second and a large white “A” was displayed on the screen to indicate the first interval. The bulb then returned to yellow for two seconds to indicate that another interval was about to occur. Then the bulb turned blue for one second and a large white “B” was displayed to indicate the second test interval. Then the bulb returned to gray, and the word “RESPOND” was flashed beneath it in white letters to indicate that the participant is supposed to respond verbally by uttering which interval they think the stimulus occurred in, “A” or “B”. The experimenter informed participants if they were correct or incorrect after every trial. This task consisted of 25 trial blocks, each block consisting of four trials. After the fourth trial of every trial block, a ten second interval occurred to give the experimenter time to prepare for the next trial block.

The participant first started with one trial block of practice trials. The first filament used was always one that delivered a force of 1.4g. If a subject was correct on all four trials of a trial block, the next weakest filament was used to deliver the stimulus on the next trial block. If the participant was correct on three of the trials in a block, the same filament was used for the following trial block. If a participant was correct on two or fewer trials, the next strongest filament was used for the next trial block. The strength of the filament used for each trial block was recorded on the data sheet. After 25 trial blocks the task ended.

Distraction Task

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Participants were in the same position as the detection task group, with their arm palm up underneath the cloth barrier. Participants receive the same stimuli as the detection group, except they were tasked with playing a computer game called Fishy!. Participants were assigned to groups using alternating assignment. A yoked-control design was used: Participants in the distraction task received the identical series of stimuli as the participant in the detection task group immediately prior. Participants were instructed to play the game, and if they lost, were to announce their final score and then begin a new game.

Line Scaling Exercise

After the initial task, participants were given a short break. After this break, a numerical scaling exercise was performed in preparation of the numerical scaling task with the nylon filaments (von Frey hairs). The experimenter did this by drawing several lines on a piece of paper, one at a time, and asking the participant to assign numbers to the lengths of the lines. The participant was told to rate the perceived length of the line on whatever number scale seemed most appropriate. Only zero and positive numbers could be used. The responses could be integers, fractions, or decimals. The only rule was that numbers should be proportional to the perceived lengths of the lines. The experimenter drew at least one line short enough to elicit a rating less than “1”, and at least one line long enough to elicit a rating greater than “10”.

Subjective Scaling of von Frey hairs

Next, the experimenter explained that more filaments would be presented, some differing in intensity from those previously presented. It was explained that the participant’s job was to rate the perceived intensity of each filament, on whatever number scale seemed most appropriate. Only zero and positive numbers could be used. Responses could be integers,

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fractions, or decimals. The only rule was that the numbers should be proportional to the sensation caused by the filament. If one filament produced a sensation twice as great as another filament, it should receive a rating twice as large as the rating assigned to the other filament.

This task began with three practice trials using different von Frey hairs spanning the range of those to be presented during archival trials. Then each of 11 filaments was presented once in random order, then this was repeated. Thus, 22 filaments in total were presented. Intensity responses were recorded after every trial. Filaments ranged in strength from 0.6g to 60g.

Weighted Rod Task

Next, participants completed a weighted-rod task. Participants were informed that this task involved multiple trials in which pressure was applied to their forearm using a weighted rod. The participant was asked to extend their right arm, palm up, through an opening in a foam-board barrier. The weighted rod was positioned about half way between the participant's wrist and elbow. For each trial, the weighted rod was lowered on to the participant's forearm for 15 seconds. The position of the participant's arm was be adjusted slightly after each trial to avoid stimulating the same spot repeatedly. Before the start of the weighted rod task, participants were reminded that if the weight became intolerable they should tell the experimenter, who would remove the weight immediately. No participant ever requested that the weight be removed prematurely.

After each trial, participants were instructed to rate the intensity of the sensation on a scale from zero to 100, where zero means no sensation and 100 means the most intense sensation imaginable. Participants were told to rate the sensation intensity as zero if they did not feel the

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rod at all. Next, participants were instructed to classify the sensation as painful, unpleasant but not painful, or neutral, in which neutral means neither pleasant nor unpleasant. Lastly, participants rated the unpleasantness of the sensation from zero to 100, zero meaning not at all unpleasant and 100 meaning the most unpleasant sensation imaginable. These three responses were recorded, and trials were carried out until all eleven trials were complete. Weights ranging from 77g to 1077g were each presented once in random order.

Final Questionnaires

Participants completed the final six questionnaires in the following order: the PILL, the BVS, the STAI, the PCS, the PANAS, and then the PVAQ. Then participants were debriefed, and awarded their research credit.

Results

Initial Group Comparisons

Initial questionnaires gathered information about participants' current pain, chronic pain, and demographics. In order to make comparisons and draw conclusions about collected data, the groups must be compared to ensure they do not show significant differences prior to the experimental manipulation. Independent-Samples Mann-Whitney U Tests were used to test group differences of age, gender, average intensity of recent pain, average unpleasantness of recent pain, percent of each day spent thinking about pain, intensity of current pain, and unpleasantness of current pain (Table 1). No significant differences between groups were found at the 95% confidence level. From this, one can conclude that the two groups can be compared.

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Table 1. Independent Samples Tests of Group Differences on Pre-Manipulation Questionnaire Items

Hypothesis Test Summary			
	Null Hypothesis	Test	Sig. Decision
1	The distribution of avg_intensity_pain is the same across categories of GROUP.	Independent-Samples Mann-Whitney U Test	.368 Retain the null hypothesis.
2	The distribution of avg_unpl_pain is the same across categories of GROUP.	Independent-Samples Mann-Whitney U Test	.126 Retain the null hypothesis.
3	The distribution of pot_day_pain is the same across categories of GROUP.	Independent-Samples Mann-Whitney U Test	.215 Retain the null hypothesis.
4	The distribution of intens_curr_pain is the same across categories of GROUP.	Independent-Samples Mann-Whitney U Test	.532 Retain the null hypothesis.
5	The distribution of unpl_curr_pain is the same across categories of GROUP.	Independent-Samples Mann-Whitney U Test	.532 Retain the null hypothesis.
6	The distribution of AGE is the same across categories of GROUP.	Independent-Samples Mann-Whitney U Test	.768 Retain the null hypothesis.
7	The distribution of GENDER is the same across categories of GROUP.	Independent-Samples Mann-Whitney U Test	.320 Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Manipulation Checks

In order to draw conclusions about group differences, it must be proven that the course of the testing session did not alter participants' emotional state in a way that could be attributed as a reason for observed changes in perception. Questionnaires used to examine this were the PCS, STAI-Y1, and the PANAS. Furthermore, group differences on measures of body vigilance were a subject of interest. Scores on the PILL, BVS, and PVAQ were analyzed to examine the effect of the experimental manipulation on body vigilance.

Independent-samples t-tests were performed to examine mean differences between all post-manipulation questionnaires (Appendix: Table 8). No questionnaires showed significant

differences at the 95% confidence interval. On the PCS, members of the experimental group tended to exhibit lower scores than members of the control group. The t-test showed a trend toward significance for the PCS, $t(78) = -1.575$, $p=.064$.

Questionnaire Correlations

A correlation matrix was computed to examine relationships between body vigilance questionnaires, and the other questionnaires administered post-manipulation. Mean questionnaire scores for each group can be found in Table 2. The PILL was significantly positively correlated with the STAI and PANAS-N; STAI: $r(78) = .334$, $p<.01$, PANAS-N: $r(78) = .446$, $p<.01$. The BVS was significantly positively correlated with the PVAQ, PCS, and PANAS-P; PVAQ: $r(78) = .700$, $p<.01$, PCS: $r(78) = .321$, $p<.01$, PANAS-P: $r(78) = .229$, $p<.05$. The PVAQ was significantly positively correlated with BVS, PCS, and STAI (Appendix: Table 7).

Table 2.

Descriptive Statistics of Post-Manipulation Questionnaires

Questionnaire	Group	Mean	Std. Deviation	Std. Error Mean
PILL	1	16.60	8.47	1.34
	2	17.38	8.84	1.40
BVS	1	18.50	6.53	1.03
	2	19.64	6.80	1.07
STAI	1	31.93	8.97	1.42
	2	31.93	8.42	1.33
PCS	1	16.38	9.33	1.47
	2	20.10	11.69	1.85
PANAS_P	1	29.93	9.20	1.45
	2	29.83	6.88	1.09
PANAS_N	1	13.53	3.12	0.493
	2	13.65	4.34	0.686
PVAQ	1	31.48	12.47	1.97
	2	36.11	14.98	2.37

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Group 1: Experimental Group (Detection Task)

Group 2: Control Group (Distraction Task)

The main effect of stimulus force was highly significant across both the VFH task and WR task. This shows that as force exerted on a participant's arm increased, they responded with higher ratings of sensation intensity. This was to be expected, but is important to test. If the main effect of force was found to be non-significant, any subsequent results would be of little to no value.

Von Frey Hair Data

To test the hypothesis that experimental manipulations would have an effect on the slope with which sensation intensity increased with regard to force, the data were transformed using logarithms to the base ten (Gescheider 298-306; Hollins et al. 2009). Sensation intensity grows exponentially as stimulus strength increases, according to the power law of psychophysics. Therefore, by taking the logarithm of both sensation intensity and stimulus strength, the data will be transformed such that the slope of transformed data is the same as the exponent with which sensation intensity increases in the linear data. (Gescheider 298-306; Hollins et al. 2009).

The logarithmically transformed data were analyzed using an 11 (Force) x 2 (Order) x 2 (Group) mixed-model ANOVA. A significant main effect of group on sensation intensity was found, with the experimental (detection task) group reporting higher sensation intensities than that of the control (distraction task) group, $F(1, 78) = 4.67, p < .05$. This shows that the experimental manipulation had an effect on participants' sensation intensities. This supports the hypotheses that direction of attention will cause an increase in sensation intensity of subsequent similar stimuli.

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Each sensation intensity was presented twice during the VFH task. Each of the eleven stimulus strengths was presented once in random order, then this same procedure was repeated to administer a total of 22 randomly ordered stimuli. There was a significant main effect of this order of presentation on sensation intensity, with the first presentation being rated significantly higher for both groups, $F(1, 78) = 20.206, p < .001$ (See Figure 1).

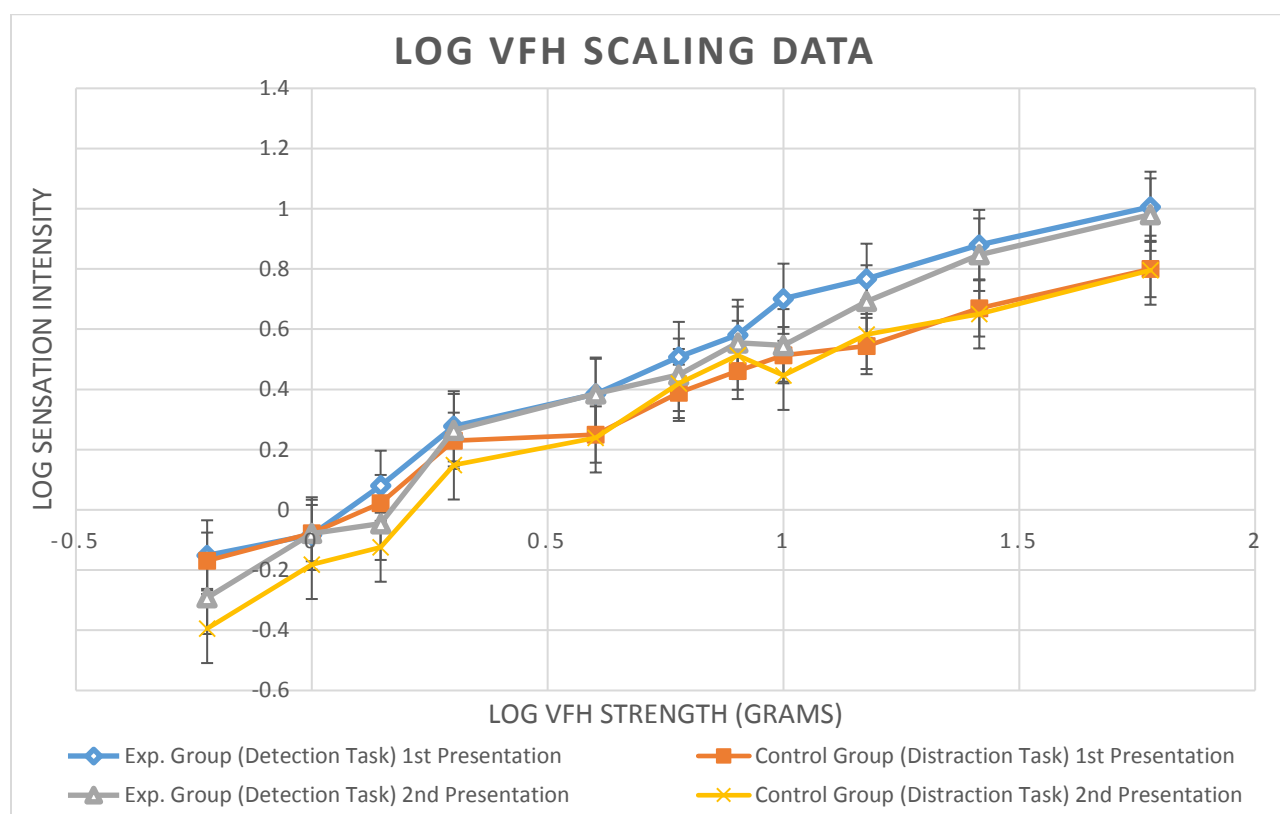


Figure 1. Logarithmic Conversion of Relationship between Sensation Intensity and Von Frey Hair

Strength Across Groups and Presentation Order

Because this effect was present in both groups, subsequent figures displaying VFH data use an average sensation intensity rating across presentation order, in order to compare groups (See Figure 2). There was a significant interaction effect between presentation order and stimulus

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force on sensation intensity. This suggests that order itself had an effect on sensation intensity, but also that the impact of force depended on the order with which the stimulus was presented.

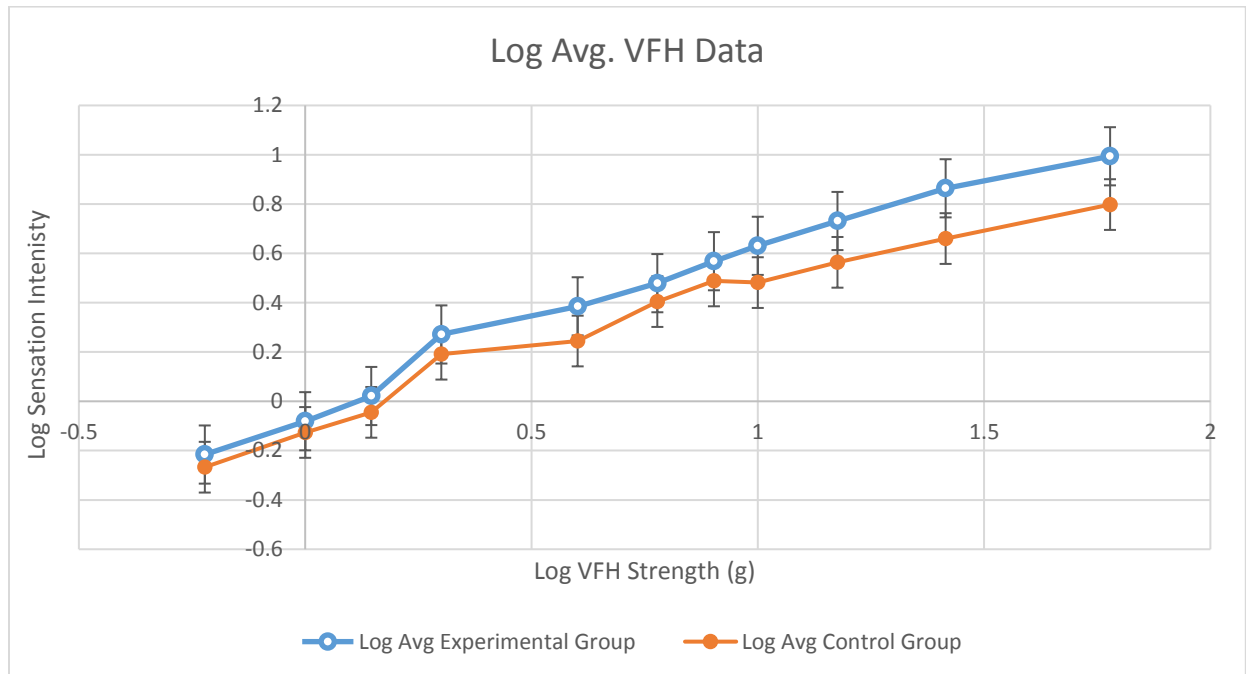


Figure 2. Logarithmic Conversion of Relationship between Average Sensation Intensity and Von Frey Hair Strength Across Groups

This effect of order likely occurred because participants encountered a new range of stimulus strengths, and then habituated to these stimuli (Hollins et al. 2011). Participants underwent three training trials, which spanned the range of the stimuli to be presented, but this was not enough to cause complete habituation. A more extensive training routine for this task would likely account for this effect of stimulus order, as it would cause habituation to occur before the recorded trials.

Weighted Rod Data

The weighted rod task utilized 11 stimuli of varying strengths. In this task each strength stimulus was presented only once. Participants were asked to rate intensity, unpleasantness, and describe the sensation as neutral, unpleasant, or painful. These data were logarithmically transformed for the same reasons as the von Frey hair data, described previously. Then, 11 (Force) x 2 (Group) mixed-model ANOVAs were run to investigate the effect of experimental manipulations on logarithmic sensation intensity and sensation unpleasantness data.

Log Intensity. There was a significant main effect of force on sensation intensity, $F(1, 78) = 183.08, p < .001$. No other variables had a significant effect on sensation intensity. A graph of the logarithmically transformed weighted rod intensity data is shown in Figure 4. This does not support the hypothesis that subjects who directed attention would experience sensations as significantly more intense than those who were distracted. This may have occurred because of the difference in the experience of sensations produced by the von Frey hairs, and the weighted rod. This suggests that amplification occurs only when sensations are very similar to those which are attended to.

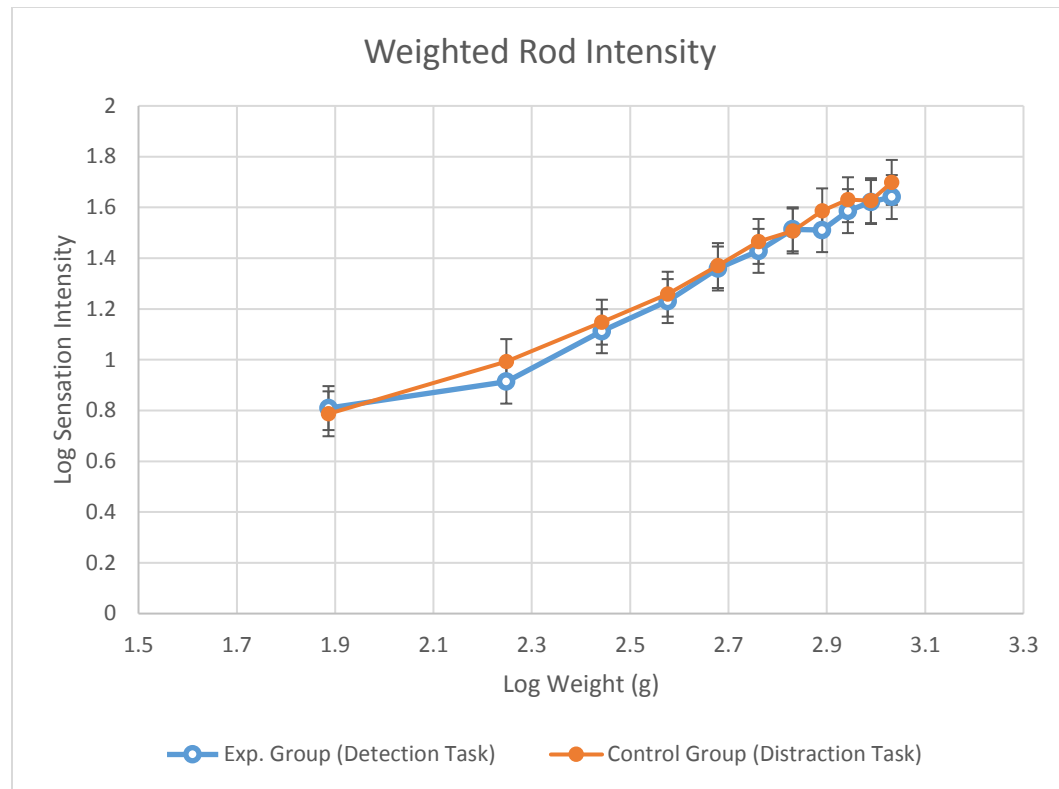


Figure 3. *Logarithmic* Conversion of Relationship between Sensation Intensity and Weight of Weighted-Rod

Log Unpleasantness. Descriptive statistics showed a tendency for the control group to rate sensations as more unpleasant than the experimental group, but this was not significant, $F(1, 78) = 1.318$, $p = .254$. There was a significant interaction of force and group $F(10, 780) = 2.231$, $p < .05$. There was not a significant main effect of group on sensation unpleasantness. However, there was a significant interaction effect of stimulus force and group on sensation unpleasantness in the logarithmically transformed data, with the control group having higher levels of sensation unpleasantness (See Figure 3). This implies that the impact of stimulus force on sensation unpleasantness was affected by group. This contradicts the hypothesis that sensation unpleasantness would be higher in the group that directed attention at light touch sensations.

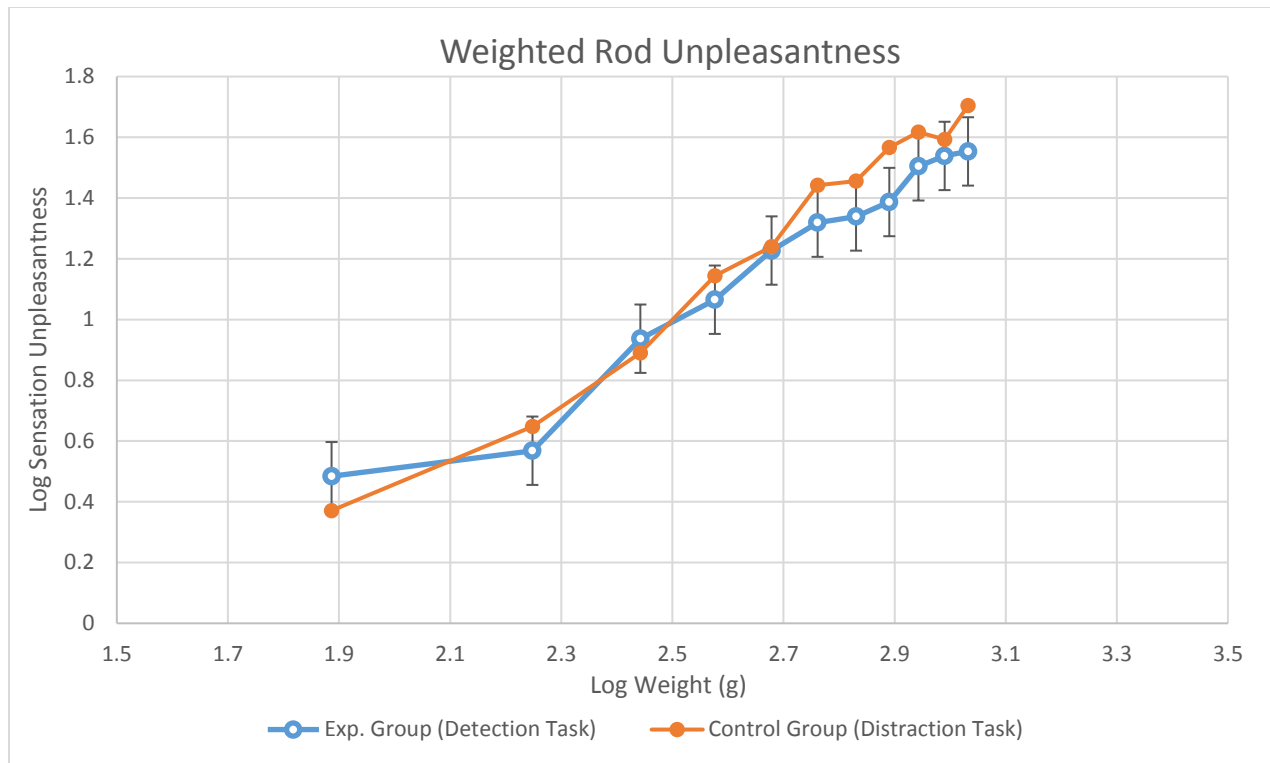


Figure 4. Logarithmic Conversion of Relationship between Sensation Unpleasantness and Weight of Weighted-Rod.

Correlations

There were no significant correlations between detection threshold during the detection task, and any vigilance questionnaires. This fails to support the hypothesis that participants with high body vigilance would be able to detect the more delicate von Frey hairs. In fact, this measure was not significantly correlated with any questionnaires used (See Table 3).

Table 3. Pearson Correlation of Post-Manipulation Questionnaires and Detection Threshold in Experimental (Detection Task) Group

PILL	BVS	STAI	PCS	PANAS Pos.	PANAS Neg.	PVAQ
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Detection Threshold	Pearson Correlation	.101	.023	.107	.049	-.011	-.133	-.109
	Sig. (2-tailed)	.537	.886	.512	.763	.947	.415	.504
	N	40	40	40	40	40	40	40

*. Correlation is significant at the 0.05 level (2-tailed).

Discussion

The findings of the current study show that the manipulation caused no significant differences between groups on vigilance questionnaires. Furthermore, there were no significant between group differences on sensation intensity or unpleasantness on the weighted-rod task. This indicates that a 100 trial task is not enough to alter overall bodily vigilance. However, the manipulation was responsible for causing significant between-group differences on the von Frey hair scaling task. This suggests that vigilance remains specific to the type of sensation being attended to, and requires other factors to generalize to other types of sensations and modalities.

Perhaps the amplification occurs only within sensations that are highly physically similar, or induce similar affect. In the present study, after 100 trials of direction of attention toward light touch sensations, participants experienced subsequent, *highly similar*, sensations as more intense. Yet, this same group did not experience amplification in the weighted rod task, which supplied stronger, blunter stimuli.

Diversified Hypervigilance

It could also be posited that for chronic pain patients, as the perceptual style of amplification is developing, a patient begins attending to sensations associated with their disease. Many chronic pain conditions have diverse sets of symptoms, which all may vary in

manifestation and severity. This could produce a wide variety of sensations, all of which would be attended to with increasing regularity.

Chronic pain conditions are very complex. Perhaps use of healthy participants in the current study has helped illustrate how the initial stages of chronic pain affect perception. The results of the current study suggest that amplification is highly specific to the type of sensation attended to. Commonly, as chronic pain conditions worsen, symptoms are accompanied by cognitive decline, often described as a mental fog. This could be due to development of a habit of attending to a large number of specific sensations. Directing attention in many directions would reasonably contribute to cognitive overload, and this direction of attention could cause each of these types of sensations to become amplified over time. As more sensations are attended to, there is increased possibility that associations between sensations would form, which would result in a perceptual style which resembles generalization of hypervigilance.

This set of symptoms would resemble something concurrent with the concept of *generalized* hypervigilance, but a more fitting explanation based on the findings of the current study is *diversified* hypervigilance. The results of this study suggest that perceptual amplification remains restricted to sensations that are very similar to that which are habitually attended to. Generalized hypervigilance occurs when a diverse set of sensations is habitually attended to, which can over time cross to different modalities like light and sound, such as is shown in Hollins et al. (2009). These results provide support for the Attentional Gain Model of hypervigilance.

The current study suggests an explanation for the origin of perceptual amplification, which is accompanied by generalized hypervigilance. This explanation is that amplification starts

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out small and specific, and over time expands its scope and severity. This explanation also posits that attention is the underlying mechanism. Most real-world cases involve a noxious motivation to direct attention, such as chronic pain. However, the current study has shown that repeated direction of attention toward neutral stimuli can also cause perceptual amplification.

Suggestion of Future Research

A future study in this domain might use a similar design as the current study, but rather than using light tactile stimuli in the experimental manipulation, this proposed study could use stimuli more similar to the weighted-rod. If this proposed study yielded significant between-group differences of weighted-rod task sensation intensity, and non-significant between group differences of von Frey hair sensation intensity, it would support the interpretation that the direction of attention is the mechanism responsible for perceptual amplification, but that amplification only occurs to sensations that are very similar to those habitually attended to.

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Appendix

Table 4.

Correlation Matrix of Post-Manipulation Questionnaires

		Group	PILL	BVS	STAI	PCS	PANAS_ P	PANAS_ N	PVAQ
Group	Pearson Correlation	1	.045	.086	.000	.176	-.006	.017	.168
	Sig. (2-tailed)		.690	.446	1.000	.119	.956	.883	.136
	N	80	80	80	80	80	80	80	80
PILL	Pearson Correlation	.045	1	.210	.334**	.123	-.148	.446**	.180
	Sig. (2-tailed)	.690		.061	.002	.278	.190	.000	.111
	N	80	80	80	80	80	80	80	80
BVS	Pearson Correlation	.086	.210	1	.112	.321**	.229*	.200	.700**
	Sig. (2-tailed)	.446	.061		.321	.004	.041	.076	.000
	N	80	80	80	80	80	80	80	80
STAI	Pearson Correlation	.000	.334**	.112	1	.288**	-.361**	.597**	.250*
	Sig. (2-tailed)	1.000	.002	.321		.010	.001	.000	.025
	N	80	80	80	80	80	80	80	80
PCS	Pearson Correlation	.176	.123	.321**	.288**	1	-.223*	.254*	.651**
	Sig. (2-tailed)	.119	.278	.004	.010		.047	.023	.000
	N	80	80	80	80	80	80	80	80
PANAS_P	Pearson Correlation	-.006	-.148	.229*	-.361**	-.223*	1	-.052	.063
	Sig. (2-tailed)	.956	.190	.041	.001	.047		.645	.581
	N	80	80	80	80	80	80	80	80
PANAS_ N	Pearson Correlation	.017	.446**	.200	.597**	.254*	-.052	1	.207
	Sig. (2-tailed)	.883	.000	.076	.000	.023	.645		.066
	N	80	80	80	80	80	80	80	80
PVAQ	Pearson Correlation	.168	.180	.700**	.250*	.651**	.063	.207	1
	Sig. (2-tailed)	.136	.111	.000	.025	.000	.581	.066	
	N	80	80	80	80	80	80	80	80

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Correlations of all post-manipulation questionnaires

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Table 5.
Independent Samples Test of Post-Manipulation Questionnaires by Group

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2- tailed)	Mean Difference	Std. Error Difference	Lower	Upper
PILL	Equal variances assumed	.012	.914	-.400	78	.690	-.77500	1.93599	-4.62926	3.07926
	Equal variances not assumed			-.400	77.86 0	.690	-.77500	1.93599	-4.62937	3.07937
BVS	Equal variances assumed	.201	.655	-.767	78	.446	-1.14292	1.49059	-4.11046	1.82463
	Equal variances not assumed			-.767	77.87 6	.446	-1.14292	1.49059	-4.11054	1.82470
STAI	Equal variances assumed	.048	.827	.000	78	1.000	.00000	1.94599	-3.87418	3.87418
	Equal variances not assumed			.000	77.68 9	1.000	.00000	1.94599	-3.87442	3.87442
PCS	Equal variances assumed	3.524	.064	-1.575	78	.119	-3.72500	2.36467	-8.43269	.98269
	Equal variances not assumed			-1.575	74.32 3	.119	-3.72500	2.36467	-8.43636	.98636
PANAS_P	Equal variances assumed	2.451	.121	.055	78	.956	.10000	1.81598	-3.51534	3.71534
	Equal variances not assumed			.055	72.20 8	.956	.10000	1.81598	-3.51991	3.71991
PANAS_N	Equal variances assumed	1.830	.180	-.148	78	.883	-.12500	.84545	-1.80817	1.55817
	Equal variances not assumed			-.148	70.81 7	.883	-.12500	.84545	-1.81086	1.56086
PVAQ	Equal variances assumed	1.358	.247	-1.505	78	.136	-4.63750	3.08228	-10.77385	1.49885
	Equal variances not assumed			-1.505	75.50 7	.137	-4.63750	3.08228	-10.77704	1.50204